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(54) Title of the present invention: EL ELEMENT AND MANUFACUTURING METHOD THEREOF

(57) [Abstract]

[Object] To provide an EL element capable of improving yield by preventing nonuniform emission caused by partial thinning of an EL layer due to sticking-out of an EL layer forming liquid, and a nonuniform film thickness portion around the EL layer.

[Solving Means] This EL element includes at least a substrate, first electrodes patterned on the substrate, an insulating layer provided between the first electrodes over the substrate, a photocatalyst containing layer formed so as to cover the insulating layer and the first electrodes, the EL layer that is formed over the first electrodes with the photocatalyst containing layer interposed therebetween and separated by the insulating layer, and a second electrode formed over the EL layer. An EL layer side surface of the insulating layer inclines to the insulating layer side from a vertical direction with respect to the EL layer side surface of the first electrodes.

[Scope of Claim]

[Claim 1] An EL element characterized by comprising at least:

a substrate;

a first electrode patterned on the substarte;

an insulating layer provided between the first electrodes over the substarte;

a photocatalyst containing layer formed so as to cover the insulating layer and the first electrode;

an EL layer which is formed over the first electrode with the photocatalyst containing layer interposed therebetween and separated by the insulating layer; and

a second electrode formed over the EL layer,

wherein an EL layer side surface of the insulating layer inclines to the insulating layer side from a vertical direction with respect to the EL layer side surface of the first electrode.

[Claim 2] An EL element characterized by comprising at least:

a substrate;

a first electrode patterned on the substarte;

an insulating layer provided between the first electrodes over the substarte;

a photocatalyst containing layer formed so as to cover the insulating layer and the first electrode;

an EL layer which is formed over the first electrode with the photocatalyst containing layer interposed therebetween and separated by the insulating layer; and

a second electrode formed over the EL layer,

wherein a nonuniform film thickness portion on the periphery of the insulating layer of

the EL layer sticks out beyond a portion in which the first electrode and the second electrode overlaps with each other when seen from a normal line direction of the EL element.

[Claim 3] The EL element according to claim 1 or 2, wherein the EL layer side surface of the insulating layer has a convex curved shape on the insulating layer side.

[Claim 4] The EL element according to claim 1 or 2, wherein the EL layer side surface of the insulating layer has a convex curved shape on the EL layer side.

[Claim 5] The EL element according to claim 1 or 2, wherein the EL layer is patterned in stripes.

[Claim 6] The EL element according to claim 1 or 2, wherein the EL layer is patterned in segments.

[Claim 7] The EL element according to claim 1 or 2, wherein the first electrode is stripe-patterned.

[Claim 8] A display formed using the EL element according to Claim 1 or 2.

[Claim 9] A full-color display formed using the EL element according to Claim 1 or 2.

[Claim 10] A method for manufacturing the EL element according to Claim 1 or 2, comprising:

a step of patterning a first electrode over a substrate;

a step of forming an insulating layer over the substrate;

a step of forming a photocatalyst containing layer over the first electrode and the insulating layer;

a step of conducting light irradiation for changing wettability of the photocatalyst containing layer to an EL layer formation region over the photocatalyst containing layer;

a step of applying or discharging an EL layer forming liquid to the EL layer formation region;

a step of forming an EL layer from the EL layer forming liquid; and

a step of forming the second electrode over the EL layer.

[Detailed Description of the present invention]

[0001]

[Industrial Field of the present invention] The present invention relates to an EL element which can be manufactured by a simple method and by which uniform light emission can be obtained, and a manufacturing method of the EL element.

[0002]

[Prior Art] EL elements have attracted attention for use as self-light emitting planar display elements. Among them, an organic thin film EL display using an organic material as an emitting material realizes high luminance light emission even when an application voltage is a little less than 10 V, and thus has high emission efficiency and is capable of emitting light with a simple element structure; therefore, it has been anticipated to be applied to a low-cost display for convenient display such as an advertisement, which performs luminescent display of a specific pattern.

[0003] As main types of a full-color display using such an EL display, the one combining an EL element and a color filter or a color conversion filter which emits fluorescent and the one in which an organic EL layer is patterned are known.

[0004] Of them, in manufacture of the latter display, as a method for patterning an organic EL layer, mask evaporation, a printing method, and an ink-jet method are given, for example. Among these film formation methods, mask evaporation has problems such as necessity of an expensive vacuum device and complicated steps since it is necessary to repeat an evaporation step depending on the number of patterns. On the other hand, in a case of applying an EL layer forming liquid in patterns by a printing method, an ink-jet method or the like, the expensive vacuum device is not necessary, and a full color display can be manufactured easily.

[0005] However, in a printing or ink-jet method, a phenomenon in which an embrocation is raised or dented in the vicinity of an insulating layer due to surface tension of the EL layer forming liquid and high or low wettability with the insulating layer, and a central portion becomes thin or thick occurs; therefore, uniformity of thickness of an EL layer of a manufactured EL element becomes a problem. Further, in a case where the EL layer forming liquid is attached to a region outside of an EL layer formation region, for example, over the insulating layer, certain film thickness necessary for the EL layer cannot be secured in some cases. Nonuniform thickness of these EL layers is a problem in that nonuniform light emission or reduction in light emission efficiency of the EL element is caused. Furthermore, there is a problem that an ink discharged from an inkjet head drops out of orbit and disperses over the insulating layer or into an adjacent cell, whereby yield is lowered.

[0006]

[Problems to be Solved by the present invention] The present invention solves the

aforementioned problems, and an object of the present invention is to provide an EL element of which EL layer is formed by an ink-jet method or the like and which allows to improve yield by preventing nonuniform light emission and reduction in emission efficiency of the EL element, which results from an EL layer having an nonuniform film thickness portion formed due to surface tension of the EL layer forming liquid and high or low wettability with the insulating layer and results from a thin EL layer formed by attachment of the EL layer forming liquid to a region outside of an EL layer formation region.

[0007]

[Means for Solving the Problem] The inventor of the present invention found that the aforementioned problems can be solved by inclining an interface of the insulating layer and the EL layer to the insulating layer side from a vertical direction with respect to an interface of the EL layer side and the first electrode, and by forming a photocatalyst containing layer so as to cover the insulating layer and the first electrode.

[0008] Therefore, an EL element of the present invention is characterized by comprising at least a substrate, a first electrode patterned on the substrate, an insulating layer provided between the first electrodes over the substarte, a photocatalyst containing layer formed so as to cover the insulating layer and the first electrode, an EL layer which is formed over the first electrode with the photocatalyst containing layer interposed therebetween and separated by the insulating layer, and a second electrode formed over the EL layer, wherein an EL layer side surface of the insulating layer inclines to the insulating layer side from a vertical direction with respect to the EL layer side surface of the first electrode.

[0009] Also, an EL element of another mode of the present invention is characterized by comprising at least a substrate, a first electrode patterned on the substrate, an insulating layer provided between the first electrodes over the substarte, a photocatalyst containing layer formed so as to cover the insulating layer and the first electrode, an EL layer which is formed over the first electrode with the photocatalyst containing layer interposed therebetween and separated by the insulating layer, and a second electrode formed over the EL layer, wherein nonuniform film thickness portion on the periphery of the insulating layer of the EL layer sticks out beyond a portion in which the first electrode and the second electrode overlaps with each other when seen from a normal line direction of the EL element.

[0010]

[Embodiment Mode of the present invention] Insulating layer

FIG. 1 is a cross sectional view showing a specific example of an EL element of the present invention. Insulating layers 2 are formed over a substrate 1, a first electrode 3 is formed between the insulating layers 2 over the substrate 1, a photocatalyst containing layer 4 is formed so as to cover the insulating layers 2 and the first electrode 3, an EL layer 5 is formed over the first electrode 3, and further, the second electrode 6 is formed thereover.

[0011] In an EL element of the present invention, as for the insulating layer, for example, an interface of the EL layer and the insulating layer covered by the photocatalyst containing layer can be inclined to the insulating layer side from a vertical direction with respect to an interface of the EL layer and the first electrode covered by the photocatalyst containing layer. Further, an interface of the insulating layer and the EL layer may have a convex curved surface on the insulating layer side or may have a convex curved surface on the EL layer side.

[0012] Further, for a cross sectional shape of the insulating layer, an upper portion of the insulating layer is preferably thinner than a lower portion of the insulating layer as shown in FIG. 1. Thus, the second electrode can be formed without being disconnected even in a case where the second electrode is evaporated from right above the EL element. In addition, the case of such a shape is preferable since the EL layer forming liquid easily moves to the first electrode between the insulating layers, to which the EL layer forming liquid should attach normally. Moreover, when the insulating layer is formed so as to cover an edge of the first electrode as shown in FIG. 1, leakage from the first electrode can be prevented, which is preferable. As a material for constituting the insulating layer, an insulating resin such as a photosensitive polyimide resin or an acrylic resin, a light curable resin, a heat-curable resin and the like can be given.

[0013] For forming the insulating layer, various methods such as dispenser application, a printing method, an ink-jet method and a photolithography method can be used. Among them, a method for patterning by using a photolithography method is preferable since for example, a shape of the insulating layer can be controlled by appropriate adjustment of distance between a mask and an application surface, light exposure, developing time and the like in exposing after a photosensitive material of the insulating layer is applied. As for a cross sectional shape of the

insulating layer, in order to make an upper portion thinner than a lower portion, specifically, a method such as extending developing time after application of a resist of the insulating layer and exposure or exposing from a rear surface of a base material can be used, for example.

[0014] <u>Photocatalyst containing layer</u>

(Photocatalyst containing layer) In the present invention, the photocatalyst containing layer generally refers to a layer of which wettability can be changed in the hereafter by light irradiation and a layer of which wettability has been changed. Further, a photocatalyst may be any material as long as it occurs such a change. The photocatalyst containing layer can be patterned depending on a change of wettability by being exposed in a pattern. Typically, a portion to be irradiated with no light has water repellency, and a portion irradiated with light has high hydrophilicity. And, in the present invention, the photocatalyst containing layer is provided between the insulating layer, and the first electrode and the EL layer.

[0015] In the present invention, a pattern of the EL layer can be simply formed with high quality with use of a pattern in accordance with wettability on the surface of the photocatalyst containing layer. Specifically, in the photocatalyst containing layer formed so as to cover the insulating layer and the first electrode, a portion over the first electrode is irradiated with light to improve wettability, and a portion over the insulating layer is not irradiated with light so that wettability remains low. When the EL layer forming liquid is attached thereto by an ink-jet method or the like, even if the EL layer forming liquid sticks out slightly, it returns over the first electrode. Therefore, a certain amount of EL layer forming liquid is supplied over the first electrode, whereby uniformity of thickness of the EL layer can be achieved.

[0016] When the photocatalyst containing layer is too thin, a difference of wettability is not clearly seen and thus, patterning becomes difficult to be performed, whereas when it is too thick, it interferes transportation of a hole or an electron and adversely affects light emission of the EL element; therefore, the thickness thereof is preferably 50 to 2000 Å, more preferably, 100 to 1000 Å.

[0017] (A principle of a change in wettability) In the present invention, a pattern in accordance with a difference of wettability is formed for a portion irradiated with light with use of a photocatalyst that can cause a chemical change in a peripheral material (binder or the like) by light irradiation. Although a mechanism of action by the photocatalyst is not always clear, a

carrier generated in the photocatalyst by light irradiation directly changes a chemical structure of the binder or the like, or reactive oxygen species generated in the presence of oxygen and water changes a chemical structure of the binder or the like, whereby wettability of the surface is considered to be changed.

[0018] (Photocatalyst material) As the photocatalyst material, for example, a metal oxide such as titanium oxide (TiO2), zinc oxide (ZnO), tin oxide (SnO_2), strontium titanate ($SrTiO_3$), tungsten oxide (WO_3), bismuth oxide (Bi_2O_3) or iron oxide (Fe_2O_3), which is known as an optical semiconductor, can be given, and in particular, titanium oxide is preferable. Titanium oxide is advantageous in having high band gap energy and no toxity, being chemically stabled, and being easily obtained.

[0019] For titanium oxide as the photocatalyst, both an anatase type and a rutile type can be used, but anatase type titanium oxide is preferable. Specifically, hydrochloric acid deflocculation anatase type titania sol (Ishihara Sangyo Kaisha, Ltd., STS-01, average crystallite diameter 7nm), and nitric acid deflocculation anatase type titania sol (Nissan Chemical Industries Ltd., TA-15, average crystallite diameter 12nm) can be given, for example.

[0020] An amount of photocatalyst in the photocatalyst containing layer is preferably 5 to 60% by weight, more preferably, 20 to 40% by weight.

[0021] (Binder component) The binder that can be used for the catalyst containing layer preferably has high bond energy such that a main skeleton is not dissolved by photoexcitation of the photocatalyst, for example, (1) organo polysiloxane which is obtained by hydrolysis and polycondensation of chloro, alkoxysilane or the like by sol-gel reaction or the like and which shows high strength, (2) organo polysiloxane which is obtained by cross-linkage of reactive silicon superior in water repellency and oil repellency, and the like can be given.

[0022] In a case of the aforementioned (1), hydrolysis condensation or cohydrolysis condensation of one kind or two or more kinds of silicon compounds expressed by a general formula Y_nSiX_{4-n} (n =1 to 3) can be a main body. In the aforementioned general formula, Y can be, for example, an alkyl group, a fluoroalkyl group, a vinyl group, an amino group or an epoxy group, and X can be, for example, halogen, a methoxyl group, an ethoxyl group or an acetyl group.

[0023] Specifically, methyltrichlorsilane, methyltribromosilane, methyltrimethoxysilane,

methyltriethoxysilane, methyltriisopropoxysilane, methyl-tri-*t*-butoxysilane; ethyltrichlorosilane, ethyltribromosilane, ethyltrimethoxysilane, ethyltriethoxysilane, ethyltriisopropoxysilane, ethyl-tri-*t*-butoxysilane; n-propyltrichlorosilane, n-propyltribromosilane, n-propyltrimethoxysilane, n-propyltriethoxysilane, n-propyltriisopropoxysilane, n-propyl-tri-t-butoxysilane; n-hexytrichlorosilane, n-hexyltribromosilane, n-hexyltrimethoxysilane, n-hexyltriethoxysilane, n-hexyltriisopropoxysilane, n-hexyl-tri-*t*-butoxysilane; n-decyltrichlorosilane, n-decyltribromosilane, n-decyltrimethoxysilane, n-decyltriethoxysilane, n-decyltriisopropoxysilane, n-decyl-tri-t-butoxysilane; n-octadecyltrichlorosilane, n-octadecyltribromosilane, n-octadecyltrimethoxysilane, n-octadecyltriethoxysilane, n-octadecyltriisopropoxysilane, n-octadecyl-tri-*t*-butoxysilane; phenyltrichlorosilane, phenyltribromosilane, phenyltrimethoxysilane, phenyltriethoxysilane, phenyltriisopropoxysilane, phenyl-tri-*t*-butoxysilane; tetrachlorosilane, tetrabromosilane, tetramethoxysilane, tetraethoxysilane, tetrabutoxysilane, dimethoxydiethoxysilane; dimethyldichlorosilane, dimethyldibromosilane, dimethyldimethoxysilane, dimethyldiethoxysilane; diphenyldichlorosilane, diphenyldibromosilane, diphenyldimethoxysilane, diphenyldiethoxysilane; phenylmethyldichlorosilane, phenylmethyldibromosilane, phenylmethyldimethoxysilane, phenylmethyldiethoxysilane; trichlorohydrosilane, tribromohydrosilane, trimethoxyhydrosilane, triethoxyhydrosilane, triisopropoxyhydrosilane, tri-t-butoxyhydrosilane; vinyltrichlorosilane, vinyltribromosilane, vinyltrimethoxysilane, vinyltriethoxysilane, vinyltriisopropoxysilane, vinyl-tri-*t*-butoxysilane; trifluoropropyltrichlorosilane, trifluoropropyltribromosilane, trifluoropropyltrimethoxysilane, trifluoropropyltriethoxysilane, trifluoropropyltriisopropoxysilane, trifluoropropyl-tri-*t*-butoxysilane; γ-glycidoxypropylmethyldimethoxysilane, γ-glycidoxypropylmethyldiethoxysilane, γ-glycidoxypropyltrimethoxysilane, γ-glycidoxypropyltriethoxysilane, γ-glycidoxypropyltriisopropoxysilane, γ-glycidoxypropyl-tri-*t*-butoxysilane; γ-methacryloxypropylmethyldimethoxysilane, γ-methacryloxypropylmethyldiethoxysilane, γ-methacryloxypropyltrimethoxysilane, γ-methacryloxypropyltriethoxysilane, γ-methacryloxypropyltriisopropoxysilane, γ-methacryloxypropyl-tri-*t*-butoxysilane; γ-aminopropylmethyldimethoxysilane,

γ-aminopropylmethyldiethoxysilane, γ-aminopropyltrimethoxysilane, γ-aminopropyltriethoxysilane, γ-aminopropyltriisopropoxysilane, γ-aminopropyl-tri-*t*-butoxysilane; γ-mercaptopropylmethyldimethoxysilane, γ-mercaptopropylmethyldiethoxysilane, γ-mercaptopropyltrimethoxysilane, γ-mercaptopropyltriethoxysilane, γ-mercaptopropyltriisopropoxysilane, γ-mercaptopropyl-tri-*t*-butoxysilane; β-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, β-(3,4-epoxycyclohexyl)ethyltriethoxysilane; partial hydrolysate of them; and composite of them are given.

[0024] Further, as the binder, in particular, preferably, polysiloxane containing a fluoroalkyl group can be used. Specifically, hydrolysis condensation or cohydrolysis condensation of one kind or two or more kinds of fluoroalkylsilane described below is given. Alternatively, a material which is generally known as a fluorine system silane coupling agent may be used.

[0025] $CF_3(CF_2)_3CH_2CH_2Si(OCH_3)_3$

$CF_3(CF_2)_5CH_2CH_2Si(OCH_3)_3$

$CF_3(CF_2)_7CH_2CH_2Si(OCH_3)_3$

$CF_3(CF_2)_9CH_2CH_2Si(OCH_3)_3$

$(CF_3)_2CF(CF_2)_4CH_2CH_2Si(OCH_3)_3$

$(CF_3)_2CF(CF_2)_6CH_2CH_2Si(OCH_3)_3$

$(CF_3)_2CF(CF_2)_8CH_2CH_2Si(OCH_3)_3$

$CF_3(C_6H_4)C_2H_4Si(OCH_3)_3$

$CF_3(CF_2)_3(C_6H_4)C_2H_4Si(OCH_3)_3$

$CF_3(CF_2)_5(C_6H_4)C_2H_4Si(OCH_3)_3$

$CF_3(CF_2)_7(C_6H_4)C_2H_4Si(OCH_3)_3$

$CF_3(CF_2)_3CH_2CH_2SiCH_3(OCH_3)_2$

$CF_3(CF_2)_5CH_2CH_2SiCH_3(OCH_3)_2$

$CF_3(CF_2)_7CH_2CH_2SiCH_3\ (OCH_3)_2$

$CF_3(CF_2)_9CH_2CH_2SiCH_3(OCH_3)_2$

$(CF_3)_2CF(CF_2)_4CH_2CH_2SiCH_3(OCH_3)_2$

$(CF_3)_2CF(CF_2)_6CH_2CH_2SiCH_3(OCH_3)_2$

$(CF_3)_2CF(CF_2)_8CH_2CH_2SiCH_3(OCH_3)_2$

$CF_3(C_6H_4)C_2H_4SiCH_3(OCH_3)_2$

$CF_3(CF_2)_3(C_6H_4)C_2H_4SiCH_3(OCH_3)_2$

$CF_3(CF_2)_5(C_6H_4)C_2H_4SiCH_3(OCH_3)_2$

$CF_3(CF_2)_7(C_6H_4)C_2H_4SiCH_3(OCH_3)_2$

$CF_3(CF_2)_3CH_2CH_2Si(OCH_2CH_3)_3$

$CF_3(CF_2)_5CH_2CH_2Si(OCH_2CH_3)_3$

$CF_3(CF_2)_7CH_2CH_2Si(OCH_2CH_3)_3$

$CF_3(CF_2)_9CH_2CH_2Si(OCH_2CH_3)_3$

$CF_3(CF_2)_7SO_2N(C_2H_5)C_2H_4CH_2Si(OCH_3)_3$

Polysiloxane containing a fluoroalkyl group described above is used as the binder, whereby water repellency and oil repellency of a portion irradiated with no light of the photocatalyst containing layer is considerably improved.

[0026] As a reactive silicone of the aforementioned (2), a compound having a skeleton expressed by the general formula described below can be given.

[0027] $-(Si\,(R^1)\,(R^2)\,O)_n-$

It is to be noted that n is an integer of 2 or larger, R^1 and R^2 are each a substituted or unsubstituted alkyl, alkenyl, aryl or cyanoalkyl group having 1 to 10 carbon atoms. Preferably, 40 mol% or less of the total can be vinyl, phenyl or phenyl halide. Further, R^1 and/or R^2 which are/is a methyl group is preferable because it has the lowest surface energy, and preferably, a methyl group is 60 mol% or more of the total and has at least one reactive group such as a hydroxyl group in an end or a side of a molecular chain.

[0028] Further, with the aforementioned organopolysiloxane, a stable organosilicon compound which does not cause a cross-linking reaction, such as dimethyl polysiloxane, may be mixed into the binder.

[0029] (Other components used for the photocatalyst containing layer) In the photocatalyst containing layer, a surfactant can be contained for reducing wettability of an unexposed portion. This surfactant is not limited as long as it is not dissolved and removed by the photocatalyst, but specifically, a fluorine or silicone nonionic surfactant, for example, a hydrocarbon surfactant such as various series of NIKKOL BL, BC, BO and BB manufactured by Nihon Surfactant Kogyo K. K., ZONYL FSN, FSO manufactured by DuPont, Surflon S-141, 145 manufactured by

Asahi Glass Co,. Ltd., MEGAFAC F-141, 144 manufactured by Dainippon Ink and Chemicals Incorporated, FTERGENT F-200, F251 manufactured by Neos Company Limited, Unidyne DS-401, 402 manufactured by Daikin Industries, ltd., Fluorad FC-170, 176 manufactured by Sumitomo 3M Ltd., and the like can be given. Alternatively, a cation or anion ampholytic surfactant may be used.

[0030] Further, in the photocatalyst containing layer, another component, for example, an oligomer or a polymer such as polyvinyl alcohol, unsaturated polyester, an acrylic resin, polyethylene, diallyl phthalate, ethylene propylene diene monomer, an epoxy resin, a phenol resin, polyurethane, a melamine resin, polycarbonate, polyvinyl chloride, polyamide, polyimide, styrene butadiene rubber, chloroprene rubber, polypropylene, polybutylene, polystyrene, polyvinyl acetate, nylon, polyester, polybutadiene, polybenzimidazole, polyacrylonitrile, epichlorohydrin, polysulfide or polyisoprene can be contained.

[0031] Furthermore, in the photocatalyst containing layer, a sensitizing dye which is a component for sensitizing photo activation of the photocatalyst may be contained. By addition of such a sensitizing dye, wettability can be changed with a small amount of light exposure or wettability can be changed by light exposure with different wavelengths. Further, in the photocatalyst containing layer, an EL material can be added, for example, a charge injecting material, a charge transporting material or a light emitting material is mixed, thereby improving an emission property of the EL element.

[0032] (A method for forming the photocatalyst containing layer) A method for forming the photocatalyst containing layer is not particularly limited, but for example, it can be formed by application of embrocation containing a photocatalyst to a base material by a method such as spin coating, dip coating, roll coating or bead coating.

[0033] In a case of using embrocation containing a photocatalyst, as a solvent which can be used for the embrocation is not particularly limited, and for example, an alcohol organic solvent such as ethanol or isopropanol can be given.

[0034] (Irradiation light for activating the photocatalyst) Irradiation light for activating the photocatalyst is not limited as long as it excites the photocatalyst. Such an irradiation light can be an ultraviolet ray, a visible ray or an infrared ray, or a shorter-wavelength or longer-wavelength electromagnetic wave or radiation ray than these rays.

[0035] For example, in a case of using anatase titania as the photocatalyst, an excitation wavelength is 380 nm or shorter; therefore, excitation of the photocatalyst can be performed by an ultraviolet ray. As a substance which emits such an ultraviolet ray, a mercury lamp, a metal halide lamp, a xenon lamp, an excimer laser or the other ultraviolet light source can be used.

[0036] EL layer

An EL layer provided for the EL element of the present invention is not limited as long as it causes electroluminescence. Further, the EL layer is provided over the first electrode with the photocatalyst containing layer interposed therebetween. Although a meniscus is generated to form a nonuniform thickness portion in some cases in the vicinity of the insuslating layer of the EL layer due to wettability and surface tension, this nonuniform thickness portion preferably sticks out from a portion where the first electrode and the second electrode overlaps with each other when seen from a normal line direction of the EL element.

[0037] In the EL layer of the present invention, a light emitting layer as an essential layer; a hole transporting layer for transporting holes to the light emitting layer, and an electron transporting layer for transporting electrons to the light emitting layer (these are collectively referred to as a charge transporting layer in some cases) as an arbitrary layer; and a hole injecting layer for injecting holes to the light emitting layer or the hole transporting layer, and an electron injecting layer for injecting electrons to the light emitting layer or the electron transporting layer (these are collectively referred to as a charge injecting layer in some cases) as an arbitrary layer can be further provided as constituents.

[0038] As these materials for constituting the EL layer, for example, following materials can be given.

[0039] (Light emitting layer)

<Pigment system> A cyclopentadiene derivative, a tetraphenyl butadiene derivative, a triphenyl amine derivative, an oxadiazole derivative, a pyrazoloquinoline derivative, a distyryl benzene derivative, a distyryl allylene derivative, a silole derivative, a thiophen ring compound, a pyridine ring compound, a perinone derivative, a perylene derivative, an oligothiophen derivative, a triphenylamine derivative, an oxadiazole dimer, a pyrazoline dimmer

<Metal complex system> A metal complex which has Al, Zn, Be or the like, or a rare earth metal such as TB, Eu or Dy as a central metal and oxadiazole, thiadiazol, phenyl pyridine, phenyl

benzimidazole, a quinoline structure or the like as a ligand, such as an aluminum quinolinol complex, a benzoquinolinol berylium complex, a benzooxazole zinc complex, a benzothiazole zinc complex, an azomethyl zinc complex, a porphyrin zinc complex or a europium complex.

[0040] <High molecule system> A polyparaphenylenevinylene derivative, a poly thiophen derivative, a polyparaphenylene derivative, a polysilane derivative, a polyacetylene derivative, a polyflorene derivative such as polyvinyl carbazole

(Doping material)

A perylene derivative, a coumalin derivative, a rubrene derivative, a quinacridone derivative, squarylium derivative, a porphyrin derivative, styryl dye, a tetracene derivative, a pyrazoline derivative, decacyclene, phenoxazone

(Hole injecting layer (anode buffer material)) A phenyl amine system, a star burst amine system, a phthalocyanine system, an oxide such as vanadium oxide, molybdenum oxide, ruthenium oxide or aluminum oxide, amorphous carbon, polyaniline, a polythiophen derivative

(Electron injecting layer (cathode buffer material)) Aluminum lithium, lithium fluoride, strontium, magnesium oxide, magnesium fluoride, strontium fluoride, calcium fluoride, barium fluoride, aluminum oxide, strontium oxide, calcium, polymethylmethacrylate, sodium polystyrene sulfonate

(Formation of the EL layer) The EL layer forming liquid is attached to the photocatalyst layer, and then curing is performed, whereby the EL layer can be formed.

[0041] In the EL layer forming liquid, a polar solvent such as water is preferably used as a solvent. The EL layer forming liquid using such a polar solvent has high wettability with the photocatalyst layer, and has high tendency to be repelled from the portion irradiated with no light; therefore, it is advantageous in patterning the EL formation liquid.

[0042] Further, as a method for attaching the EL formation liquid to the photocatalyst layer, typically, an ink-jet method can be given, but it is not limited thereto.

[0043] In the EL element of which EL layer is formed using the EL formation liquid in the form of liquid by an ink-jet method or the like, the EL layer is usually raised in the vicinity of an insulating layer due to high wettability and surface tension between the insulating layer and the EL layer forming liquid and high wettability with the insulating layer in many cases. The present invention is useful not only in the case where the EL layer is thus raised but also in a case

where the EL layer is dented in the vicinity of the insulating layer due to low wettability between the insulating layer and the EL layer forming liquid, and in a case where thickness of the EL layer is changed in the vicinity of the insulating layer due to various causes.

[0044] In the EL element of the present invention, for example, the EL layer can be patterned in stripes, or the EL layer can be patterned in segments.

[0045] Electrode

In the EL element of the present invention, an electrode provided over a substrate first is referred to as a first electrode, and an electrode provided over an EL layer is referred to as a second electrode. Although these electrodes are not particularly limited, electrodes preferably include an anode and a cathode, and the first electrode may be either an anode or a cathode. Either an anode or a cathode is transparent or semi-transparent. As an anode, a conductive material having a high work function is preferable so that a hole is easily injected, whereas as a cathode, a conductive material having a high electron affinity is preferable so that an electron is easily injected. Alternatively, a plurality of materials may be mixed. Both electrodes preferably have as low resistance as possible, and generally, a metal material is used, but an organic or an inorganic compound may be used.

[0046] Specifically, as a preferable anode material, ITO, indium oxide, gold and polyaniline are given, and as a preferable cathode material, a magnesium alloy (MgAg or the like), an aluminum alloy (AlLi, AlCa, AlMg or the like) and metal calcium are given. Further, the first electrode can be patterned in stripes, or the first electrode can be patterned in segments.

[0047] Substrate

In the EL element of the present invention, a substrate is provided, over which an electrode or an insulating layer is provided, and a material of the substrate is not particularly limited. Although it is desired that it be formed of a transparent material, it may be formed of an opaque material.

[0048] Use

The EL element of the present invention is preferably used for a display, more preferably, a full-color display.

[0049] A method for manufacturing the EL element

The EL element of the present invention is formed through at least a step of patterning the first electrode over the substrate, a step of forming the insulating layer over the substrate, a step of

forming the photocatalyst containing layer over the first electrode and the insulating layer, a step of conducting light irradiation for changing wettability of the photocatalyst containing layer to an EL layer formation region over the photocatalyst containing layer, a step of applying or discharging the EL layer forming liquid to the EL layer formation region, a step of forming an EL layer from the EL layer forming liquid, and a step of forming the second electrode over the EL layer. Each step can be conducted as described above or in the same manner as in the conventional method for forming an EL element. When forming a fine pattern, a cathode separator is provided in a vertical direction with respect to a pattern of the first electrode, whereby the second electrode is separated.

[0050]

[Embodiment] Embodiment 1

(Formation of an ITO pattern substrate) After an ITO as a first electrode is formed over a cleaned glass substrate by sputtering to a thickness of 1500 Å, an ITO electrode pattern is formed having a line width of 82 μm and a pitch of 18 μm by photolithography.

[0051] (Formation of the insulating layer) After a base material provided with an ITO pattern is spin-coated with a positive resist (ZPP-1850 manufactured by Zeon Corporation) so that a dry thickness thereof is 1 μm, baking is performed for 90 seconds at 110°C. Thereafter, a portion around a pitch portion with the ITO is exposed within a width of 75 μm to 365 nm UV light of 150 mJ with use of a photo mask. At this time, exposing is performed by provision of a gap of 1mm between the photo mask and the substrate. After this is developed for 70 seconds using a TMHD solution of 2.38% as a developing solution, baking is performed for an hour at 130°C, and thus an insulating layer with a shape shown in FIG. 2 is obtained.

[0052] (Formation of the cathode separator) Spin coating is performed with a negative resist (ZPN-1100 manufactured by Zeon Corporation) so that a dry thickness thereof is 4 μm, drying is performed for 90 seconds at 90°C with a hot plate. Thereafter, a mask is formed with a line width of 20 μm over an insulating layer in a vertical direction with respect to the ITO pattern, exposing is performed with a UV light of 60 mJ, and then baking is performed for 60 seconds at 110°C. Further, developing is performed for 70 seconds using a TMAHO solution of 2.38%. Thus, an inversely tapered cathode separator is formed.

[0053] (Formation of the photocatalyst containing layer and a wettability pattern) As an

embrocation for the photocatalyst containing layer, an application solution in which

· Titanium oxide sol (manufactured by Ishihara Sangyo Kaisha, Ltd., STS-01) ··· 0.3 parts by weight,

· Tetraethoxysilane ··· 0.1 parts by weight,

· Fluoroalkoxysilane (manufactured by Tohchem Products Co., Ltd., MF-160E) ··· 0.001 parts by weight,

· 2 N of hydrochloric acid ··· 4 parts by weight, and

· Isopropyl alcohol ··· 7.5 parts by weight

are mixed is applied over a substrate provided with this insulating layer by a spin coater, hydrolysis and polycondensation reaction are proceeded by drying treatment for 10 minutes at 150°C, and thus a transparent photocatalyst layer in which a photocatalyst is firmly fixed in organo siloxane is formed to a thickness of 20 nm.

[0054] As shown in FIG. 3, light irradiation is performed only on a portion, in which the first electrode between insulating layers is formed, of the obtained photocatalyst layer through a mask to change wettability. As light irradiation, a pattern is irradiated with light by a mercury lump (wavelength of 365 nm) of 70 mW/cm^2 for 50 seconds. When a water contact angle of a portion irradiated with light and a portion irradiated with no light is measured with use of a contact angle measuring device (manufactured by Kyowa Interface Science Co., Ltd., CA-Z type) 30 seconds after dropping of water from a micro syringe, it is confirmed that a water contact angle in the portion irradiated with no light is 142 degrees, whereas a water contact angle in the portion irradiated with light is 10 degrees or smaller, and pattern formation is possible in accordance with a difference between wettability of the portion irradiated with light and wettability of the portion irradiated with no light.

[0055] (Formation of an organic EL layer)

Adjustment of an embrocation containing a light emitting material

An embrocation (EL layer forming liquid) of following composition is adjusted.

· Polyvinyl carbazole ··· 7 parts by weight

· Emitting dye (R, G, B) ··· 0.1 parts by weight

· Oxadiazole compound ··· 3 parts by weight

· Toluene ··· 5050 parts by weight

They have structure formulas described below.

[0056] A structure formula of polyvinyl carbazole

[Chemical Formula 1]

A structure formula of oxadiazole compound

[Chemical Formula 2]

A structure formula of emitting dye (G) coumalin 6

[Chemical Formula 3]

Emitting dye (R) Nile red

[Chemical Formula 4]

Emitting dye (B) perylene compound

[Chemical Formula 5]

Application of an embrocation containing a light emitting material

After embrocations of colors of R, G and B are applied over the photocatalyst containing layer irradiated with light in a pattern by an ink-jet application apparatus so that they are arranged alternately, drying is performed for 30 minutes at 80°C. Accordingly, light emitting layers of three colors, each having a thickness of 1000 Å are alternately formed only in the portion irradiated with light.

[0057] (Formation of the cathode) As the second electrode, LiF having a thickness of 5 nm and Al having a thickness of 2000 Å are evaporated, and formed having a line width of 76 μm and a pitch of 30 μm in a vertical direction with respect to an ITO line by a cathode separator. Thus, a full-color display is manufactured.

[0058] Embodiment 2

A black-and-white display is manufactured in the same manner as in Embodiment 1 except that the EL emrocation of a single color (G) is applied using a dip coater instead of the ink-jet apparatus.

[0059] Comparative Example 1

A full-color display is manufactured in the same manner as in Embodiment 1 except that after a negative resist (ZPN-1100 manufactured by Zeon Corporation) is used as an insulating layer and a portion around a pitch portion without the ITO is exposed within a width of 30 μm to light of 60 mJ with use of a photo mask, heating is performed for 60 seconds at 110°C, and further, developing is performed for 70 seconds using a TMAHO solution of 2.38%, and then vacuum drying is performed. FIG. 4 shows a cross sectional view before formation of the EL layer.

[0060] Comparative Example 2

A full-color display is manufactured in the same manner as in Embodiment 1 except that an insulating layer is not provided. FIG. 5 shows a cross sectional view before formation of the EL layer.

[0061] (Lighting evaluation of a display) In displays of Embodiments 1 and 2 and Comparative Examples 1 and 2, overall light emission is performed, whereby emission nonuniformity is visually evaluated. As a result, it is confirmed that more uniform light emission can be obtained in those of Embodiments 1 and 2 as compared to those of Comparative Examples 1 and 2.

[0062]

[Effect of the present invention] By the present invention, an EL element capable of improving yield by preventing disconnection of the second electrode and nonuniform emission caused by partial thinning of an EL layer due to sticking-out of an EL layer forming liquid and a nonuniform film thickness portion around the EL layer in order to improve emission efficiency and increase an emission region.

[Brief Description of the Drawings]

[FIG. 1] A cross sectional view showing the EL element of the present invention.

[FIG. 2] A cross sectional view showing a shape of the insulating layer in Embodiments of the present invention.

[FIG. 3] A cross sectional view showing a condition before formation of the EL layer in

Embodiments of the present invention.

[FIG. 4] A cross sectional view showing a condition before formation of the EL layer in Comparative Example 1 of the present invention.

[FIG. 5] A cross sectional view showing a condition before formation of the EL layer in Comparative Example 2 of the present invention.

[Explanation of Reference]

1	substrate
2	insulating layer
3	first electrode
4	photocatalyst containing layer
4'	photocatalyst containing layer of which wettability is improved by light irradiation
5	EL layer
6	second electrode